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Volume 16 Number 1 Winter 1986

noaa

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Volume 16

Number 1

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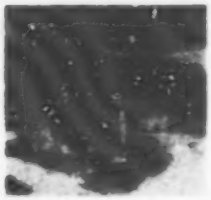
COVER: Winter comes to the coast—in this case, Pawtuxet Cove, Cranston, R.I.



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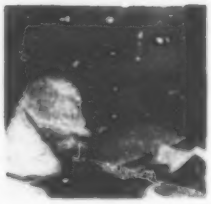

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U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
Anthony J. Calio, Administrator

A. Joseph LaCovey
Director, Public Affairs

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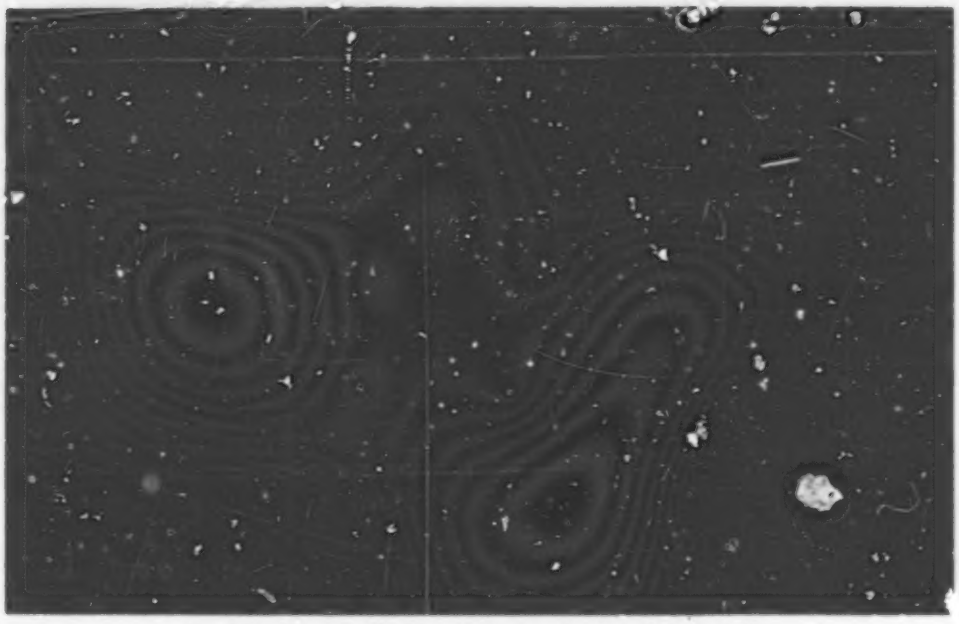
Dr. Anthony J. Calio
NOAA's New Administrator



Dr. Calio, his wife, Cheryll, and Commerce Secretary Malcolm Baldrige participate in the swearing-in ceremony in Washington.

Dr. Anthony J. Calio was sworn in as Administrator of the National Oceanic and Atmospheric Administration on October 7, 1985, following his nomination by President Reagan and Senate confirmation.

As Administrator, Dr. Calio establishes federal policies and directs agency programs to improve the understanding, management, conservation, and development of America's marine and atmospheric resources.

Under Dr. Calio's direction, NOAA is responsible for investigating and understanding the chemical and physical state of our oceans and atmosphere; predicting weather and issuing severe storm warnings and forecasts to protect life and property; promoting the wise development and conservation of our living marine, coastal, and deep seabed mineral resources; and preserving endangered marine species, marine animals, and unique estuarine areas for the future.

In addition, Dr. Calio advises and represents the Secretary of Commerce on issues involving the environment, fisheries, space and high technology, and serves on the National Security Council Interagency Group on Space. He had been NOAA's Deputy Administrator since December 1981.

Before joining NOAA, Dr. Calio was 18 years with the National Aeronautics and Space Administration where, as Associate Administrator for Space and Terrestrial Applications, he managed the U.S. civil remote sensing and space communications programs. He also had management responsibility for the Viking and Voyager missions, and during eight years at the Johnson Space Center he directed all scientific aspects of the Apollo Lunar and Skylab programs.

Prior to joining NASA in 1963, Dr. Calio was 10 years in private industry with the Mount Vernon Research Company, the American Machine and Foundry Company, and the Westinghouse Atomic Power Division where he was involved in pioneering work on the peaceful use of nuclear energy.

Dr. Calio is a fellow of the American Institute of Aeronautics and Astronautics and the American Astronautical Society, as well as a member of the American Geophysical Union. He has received numerous honors, including a Sloan Fellowship from the Stanford Graduate School of Business and NASA's Distinguished Service Medal (twice), the Exceptional Scientific Achievement Medal, the Exceptional Service Medal, and the Presidential Rank of Distinguished Executive.

Born in Philadelphia, October 1929, Dr. Calio graduated from the University of Pennsylvania with a B.A. in physics in 1953. He attended graduate school at the University of Pennsylvania and Carnegie Institute of Technology, and received a D.Sc. (Hon.) from Washington University of St. Louis in 1974. He and his wife, Cheryll Madison Calio, reside in Potomac, Maryland.

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Newsline

National Habitat Program Study Set

NOAA and the Army have signed a cooperative agreement for a pilot study to investigate the practicality of a national program for restoring and creating fisheries habitats. It will be conducted over a 3-year period in two National Marine Fisheries Service regions, and will involve two or more divisions and districts of the Army's Corps of Engineers. Such a national program would contribute toward balancing habitat conservation with the orderly development and management of the Nation's water resources.

New Frequency To Save Lives

A new radio frequency—406 Megahertz (MHz)—extending the reach of search and rescue satellites to every corner of the globe, has been adopted by the multi-nation lifesaving organization, COSPAS/SARSAT. In less than 3 years of operation the spacecraft, using an outmoded emergency signal system, have figured in the rescues of more than 500 sailors and flyers in the Northern Hemisphere, the only area where search-and-rescue ground stations exist. With the new system, satellites can monitor the entire world, do so faster, and with a 1- to 3-mile accuracy. The present system consists of three Soviet and two American polar-orbiting satellites, on-board instruments provided by Canada and France, plus 10 ground stations operated by the United States, Canada, France, Norway, the U.S.S.R., and the United Kingdom. NOAA manages the program in the United States.

Wind Network For Central States

NOAA will install a network of 30 wind measurement systems in nine central states, to demonstrate their potential for improving forecasts and to obtain research observations. The ground-based profilers will provide windspeed and direction readings at altitudes up to 10 miles every half hour, according to the Environmental Research Laboratories' Dr. Vernon E. Derr. The information is now available only once every 12 hours, from balloons. The network, to be completed by 1989, will have units in Nebraska, Kansas, Oklahoma, Iowa, Missouri, Colorado, Arkansas, Louisiana, and Texas.

NOAA Boosts Surimi Industry

NOAA is betting $2.1 million that Yankee ingenuity will gain a larger share of a traditionally Japanese market—for surimi, a protein paste made from whitefish that can be shaped and flavored to look and taste like such delicacies as scallops, shrimp, or lobster. The National Marine Fisheries Service is sponsoring production of 1.2 million pounds of surimi through a contract with the Alaska Fisheries Development Foundation. The product is being distributed to U.S. food manufacturers at a cost of 40 cents to $1.10 per pound. About 100 companies have received the surimi, and are racing to create new products—and, incidentally, to try to reduce the staggering imbalance in U.S. Japanese trade.

Hot Stuff On Atlantic Seafloor

High-temperature venting through the seafloor has been discovered in the Atlantic for the first time by NOAA researchers. The hot, mineral-rich fluids are coming up through the slow-spreading seafloor 1800 miles east of Miami, it was learned by a team headed by Peter Rona of the Atlantic Oceanographic and Meteorological Laboratories. The only other high-temperature vents have been found in the Pacific, where seafloor movement is 3 to 10 times greater than along the mid-Atlantic Ridge. It may mean that the effect upon the ocean of hydrothermal venting, including creation of massive sulfide mineral deposits, is greater than previously believed.

Lightning Detection Network Planned

Plans to create a national network for detection of lightning, which kills more Americans than floods, hurricanes, or tornadoes, have been announced by the office of the Federal Coordinator for Meteorological Services and Supporting Research. The office's Interdepartmental Committee, with representatives from 15 Federal agencies, moved to launch such a plan after a study of lightning detection systems across the country revealed programs of widely varying nature, with equally diverse methods of archiving.

At NESDIS: Two Big Winners

NOAA satellite controllers scored the year's second major save in August when the GOES-6 unaccountably turned its back from 22,000 miles in space, and began seeing stars, not the Earth. Over the next 4½ hours, controllers and engineers at the Suitland and Wallops centers sent 14 groups of 256 commands to reset counters so the imager would come on when the spacecraft next faced the Earth. In May, the $50-million NOAA-8, spinning uselessly in space for nearly a year, was tweaked back to life by NOAA, NASA, and RCA specialists who used the pull of the Earth's magnetic field to halt the spacecraft's tumbling and spinning, to stabilize it, and to return it to work.

Near-Record Fish Catch in '84

U.S. fishermen landed 6.4 billion pounds of fish and shellfish in 1984, down slightly from 1983 but close to the 1980 record of 6.5 billion pounds, with new highs set for pollock, clams and scallops. The price paid for the fish at the dock $2.4 billion—was $5 million less than in 1983. During the same period, foreign nations caught more fish within the 200-mile conservation zone than in 1983, but less than the average for the preceding 5 years. The National Marine Fisheries Service says foreign nations harvested 3 billion pounds of fish and shellfish, compared to 2.9 billion in 1983. Meanwhile, the U.S. share of fish from the 200-mile zone increased to 50 per cent of all fish taken, highest since the zone was created in 1977.

NOAA Models El Nino Conditions

Researchers from NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, N.J., have developed a computer model that simulates ocean conditions in the tropical Pacific, home of the dreaded El Nino. Dr. George Philander said the model has been used in a "remarkably realistic" simulation of the 1982-83 El Nino, blamed for a series of weather events that claimed scores of lives and wrought billions of dollars in damage. The model will join the National Weather Service's El Nino watch at the National Meteorological Center next year, as scientists seek to provide monthly-to-seasonal forecasts of climate change.

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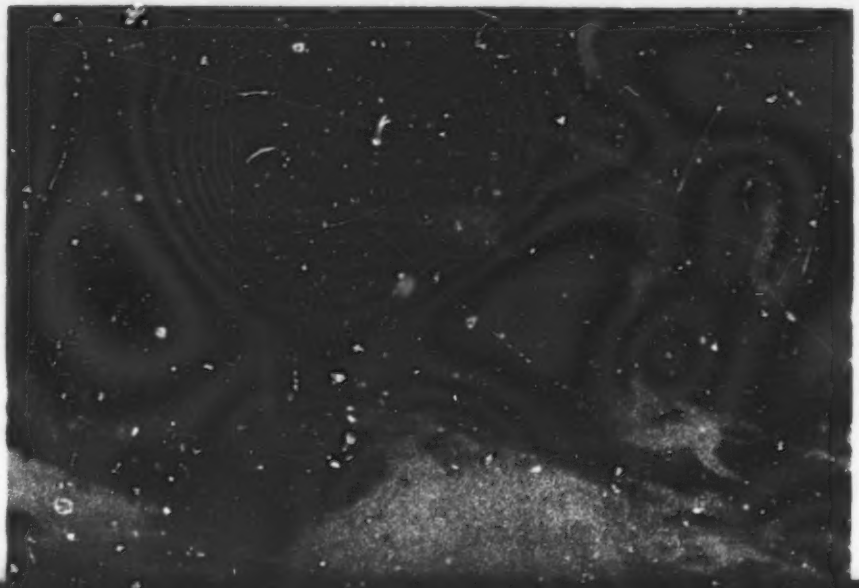
Environmental Trouble Shooters

Will Ernst *

"Near dawn at six a.m. Eastern Standard Time, Wednesday, December 15, 1976, the Liberian tanker Argo Merchant went aground on Fishing Rip, an area of treacherous shoals 29 nautical miles southeast of Nantucket. Within a few hours the U.S. Coast Guard Atlantic and Gulf Strike Teams were on the scene attempting to refloat the stricken ship, and prevent its cargo of 7.7 million gallons of number 6 fuel from spilling into the sea.

"But the Argo Merchant remained aground and, buffeted by rough seas and high winds, began to leak oil that afternoon. At 6:35 a.m. on December 21, the battered vessel began to break up spilling virtually all its oil into the rough waters off Massachusetts. The grounding of the Argo Merchant had become one of the largest oilspills in United States history." (From "The Argo Merchant Oil Spill—A Preliminary Report"—NOAA, 1977.



After several days during which scientists—and most of the world—watched with apprehension, the Argo Merchant's oil slicks were pushed out into the Atlantic by winds and currents of the Gulf Stream. There was some damage, but the U.S. coast was spared a major environmental catastrophe.

As dangerous as it was, there was one positive aspect to the wreck of the Argo Merchant. The spill provided two major tests of a plan devised half a dozen years

* *Will Ernst is an Information Management Specialist with NOAA's Hazardous Materials Response Branch in Seattle.*

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before—the National Contingency Plan, inspired by the Clean Water Act of 1970. As it turned out, the 1976 spill revealed flaws in the plan. Better coordination was needed to let scientists contribute their skills in a fast, organized fashion when disaster struck.

The plan was rewritten and from the lessons of the Argo Merchant came a nationwide network of Scientific Support Coordinators—a new breed of environmental trouble shooters. NOAA is charged with handling coastal zone pollution incidents; the Environmental Protection Agency handles inland spills.

NOAA's Scientific Support Coordinators (with the government's passion for abbreviation they quickly became SSCs) report to the operation's headquarters in Seattle, the Hazardous Materials Response Branch of the National Ocean Service's Ocean Assessments Division under the leadership of John H. Robinson.

They are men and women familiar with a wide range of concerns involving numerous sciences, and have the technical know-how of the infinity of disciplines that can come into play when an oil or chemical spill occurs. During a spill, they become key players in the drama; pooling years of training and experience in a dozen disciplines and funneling scientific advice to on-scene Coast Guard coordinators.

They are ready to go at a moment's notice to any of the thousands of spills that occur on U.S. coasts every year. NOAA's HAZMAT (for hazardous materials) organization has coordinators in Boston, New York, Norfolk, Miami, New Orleans, San Francisco, Seattle, and Anchorage.

The SSC's have wide-ranging skills and backgrounds. All have college degrees. Six are NOAA Corps officers, including Cdr. Stewart McGee, civil engineering; Lt. Dave Kruth, physical sciences and chemistry, Lt. Cdr. Todd Baxter, Fisheries; Lt. Skip Fox, geology; Lt. Cdr. Ted Keiser, geology; and Lt. (jg) Sharon Christopherson, who has a doctorate and specializes in human and diving physiology. Other specialists include Dave Kennedy, anthropology; Gary Ott, physiology and education; and Ann Hayward Walker, who has a master's in business administration.

Any day might bring such questions as "what will happen to fish in the area of a benzaldehyde spill in Baltimore?" or, "We've just had a container ship accident involving ammonia and acrylonitrile and we need to send people in to stop the leaks. Is this mixture of chemicals particularly dangerous?"

Answering such questions quickly and in a way that is useful to an emergency response unit requires a superlative team approach. Within an hour of the July 1984 explosion aboard the MV Rio Neuguen, a container ship berthed in the Port of Houston, team members were mobilized for a round-the-clock effort that went on for nearly a month.

Clouds of corrosive, poisonous and explosive phosphine vapor, generated from a container of an aluminnum phosphide pesticide, filled the ship's hold and began to drift over the port industrial area. One worker was killed by the blast and nine others were hospitalized.

Within 20 minutes of the explosion, the HAZMAT team moved into action. Dr. Jerry Galt, Glen Watabayashi, and Debbie Payton of the team's physical processes modeling group determined the various ranges of exclusion and safety zones around the accident site. These judgments were based in part on the strength of the source, the density of the vapor, and existing weather conditions. At the same time, Dr. Ed Overton, Dave Kummerlowe, and the author made a quick study of the two chemicals involved. They determined that phosphine was being formed from the ruptured container in the hold of the ship as the by-product of the aluminum phosphide product and the humidity in the air.

It was then learned that about 7,000 aluminum canisters, packaging for the 12.5 tons of pesticide product, were scattered about the hold of the ship. Many were continuing to release noxious and explosive phospine vapors. The integrity of the canisters became vital. HAZMAT located a similar container from a Seattle pest control firm and conducted structural tests on the flask. They also analyzed characteristics of the product itself to understand better the processes out of control in Houston, where the hot, muggy summer air was ideal for continued formation of phosphine vapor.

Within minutes NOAA provided the Coast Guard, by telephone, with critical information about possible evacuation zones and data covering victim and worker safety concerns. About 2 hours later, NOAA Chemical Advisory Reports which contain chemical summaries and response recommendations were furnished for both poisons enroute by computer mail to be cross-checked by toxicologists in the Center for Disease Control in Atlanta and soon were in the hands of the Coast Guard where they were valuable during the next few days.

During the MV Rio Neuguen incident, the team was led by John Robinson in Seattle and SSC Todd Baxter and Assistant SSC David Kruth stationed in Houston and Galveston respectively. Each request for information from the Coast Guard was funneled through these focal points to prevent the confusion among players that is common in the larger spills.

During the largest oil spill in history, the 1979 IXTOC oilwell blowout in the Bay of Campeche, Mexico, hundreds of scientists from federal agencies (including many from NOAA components and state and private groups were brought together for many months. This gathering conducted field studies, analyzed events and reviewed the many strategies and tactics available to the nation to limit the damages and costs posed by the blowout. Individuals, some working out of their motel rooms, operating computer terminals established links with distant offices and data bases. Overflights were conducted using C-130 aircraft flying out of Corpus Christi. NOAA divers went into the affected waters to determine the amount of oil below the surface that could not be observed from above. Oil samples were taken for analysis and delivered by car to nearby laboratories of the National Marine Fisheries Service. The NOAA Scientific Support Coordinator oversaw all these efforts and then coordinated the findings and recommendations for presentation to the Coast Guard On-Scene-Coordinator.

In a more recent incident, on September 28, 1985, over 400,000 gallons of crude

During a hazardous materials incident in Puerto Rico last year, an oil boom protects the open water from contamination.

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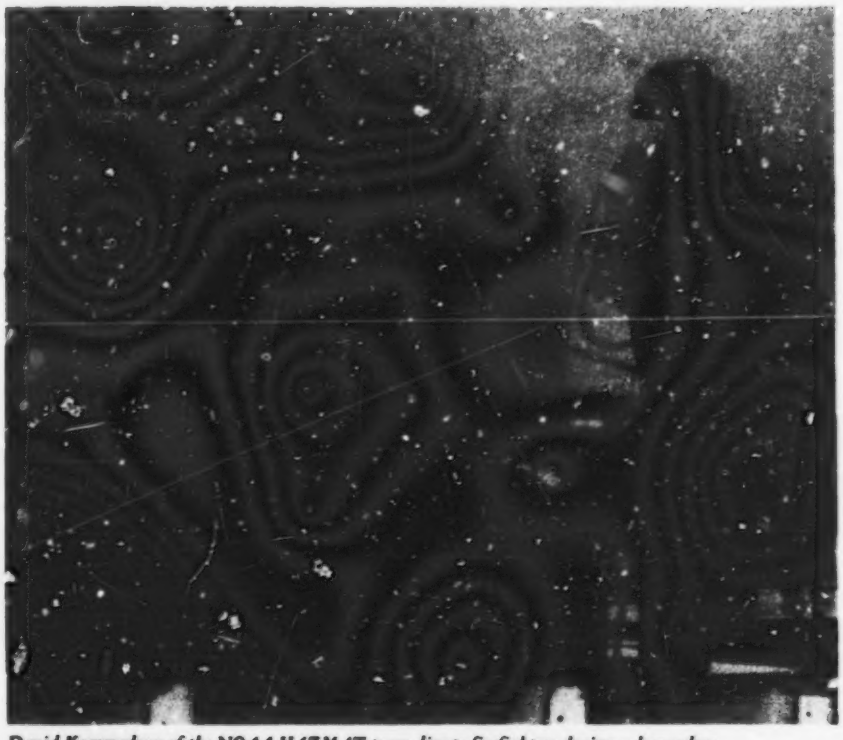
oil spilled into the Delaware river following the grounding of the tanker T/V Grand Eagle. The Coast Guard requested NOAA support and a team of HAZMAT personnel were assembled, under the local SSC overnight.

The assorted problems and issues required the involvement of a number of NOAA components. The National Weather Sevice provided individualized weather forecasts for sections of the Delaware River specifically threatened by the floating oil. In addition the National Weather Service provided data concerning the existing water levels and flow rates of the river which, at the time, was being dominated by the effects of Hurricane Diane. This data and information provided by other sources were incorporated, by HAZMAT personnel located in Seattle into a series of oil spill trajectory forecasts. A series of reports and maps providing a visual representation of the expected movement of the oil was transmitted by computer to the team onsite. Shore impact reports including the amounts of oil involved and evaporation rates, were developed and provided to the Coast Guard.

In addition to their operational responsibilities, SSCs are charged with viewing every incident as a valuable research opportunity. If conditions and timing permit, research interests are provided a real-life laboratory to aid in the development of tools and knowledge which may improve our ability to respond to the next event. In this capacity, a unit of NOAA's National Ocean Service became involved during the Delaware River spill, adapting a real-time tidal height measuring system to the problems of predicting the daily movement of the floating oil.

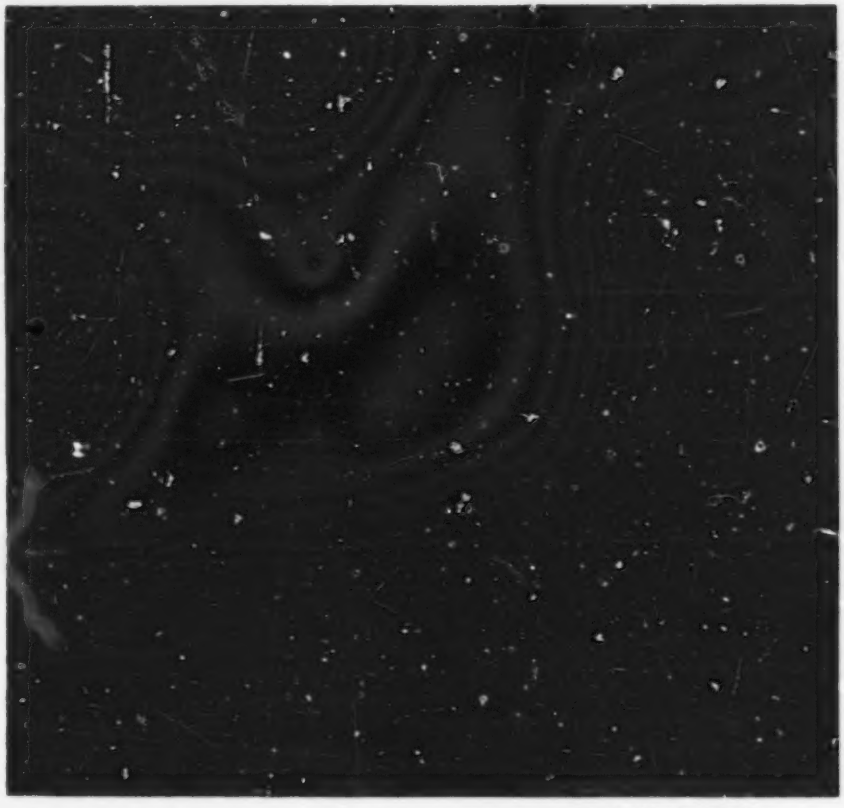
The role of communications coordinator was particularly important in July and August of 1984 during the Rio Neuguen explosion. While HAZMAT was working on response and disposal problems associated with the Houston incident, a 3.2 million gallon crude oil spill occurred off the coast of Louisiana, the total cargo of the MV Alvenus. Again, the Coast Guard requested assistance, from HAZMAT, this time to help design shoreline and environmental protection and cleanup. A NOAA team of about six scientists worked out of Galveston for nearly 2 weeks on that spill. Daily overflights and beach surveys were conducted to map the spread of oil and sampling crews performed missions to determine and document the possible damage resulting from the spill.

Although it wasn't evident then, the demands of serving the Coast Guard simultaneously at two major spills were a good



David Kammerlouw of the NOAA HAZMAT team directs firefighters during a hazardous materials response exercise.

The MV Burmah Agate on fire and discharging oil near the Port of Galveston, Tex., in November of 1979.



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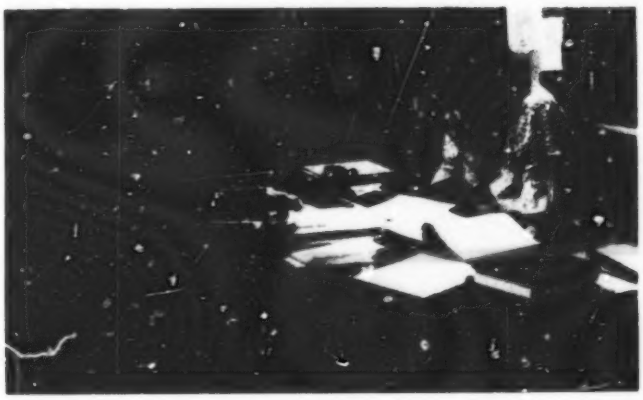

HAZMAT team members (clockwise from above): Robert Pavia is assisted by Karen Gleason in preparing for entry into a contaminated area; Phillip Shon of the Research Planning Institute confers with a member of the Coast Guard Strike Force during a drill; Dr. Gerry Gault inspects equipment for use during operations in Kuwait; the spill response center in Seattle; author Will Ernst confers with Tracey DeVaan on team operations.

test of the NOAA and federal spill response organizations. It was probably the first time HAZMAT worked from the same city on two spills. The chore of the HAZMAT information management group was particularly important in sorting out simultaneously the useful and the irrelevant information concerning each effort.

The HAZMAT team responds to about 250 major spill incidents a year, each lasting an average of 2 or 3 days. If there is any one thing each spill has in common with the others, it's that information received at the onset of a response is seldom complete and accurate. The first several hours of a response are devoted to separating fact from fiction. The spill problem almost never turns out to be the way it's first described.

A 500-gallon diesel spill in Cook Inlet, Alaska, a relatively minor amount of product when spilled in the open waters of Alaska, became a 5,000-barrel spill (220,000 gallons) of jet fuel which caused considerable concern for several days.

A barge carrying 300,000 gallons of a urea fertilizer was reported to have run aground in Chesapeake Bay in an open-water region. Closer investigation revealed that the grounding occurred in a shallow, extremely sensitive inner-water area of the bay.

A tank truck in a port industrial area was reported to have leaked 5,000 gallons of a particularly hazardous chemical product. At the time the leak was reported to HAZMAT, it was described as being at a rate of about 5 drops per minute. As it turned out, it was a 5,000-gallon capacity tank truck with a very slight valve leak. The situation was serious (the drop was eating into the concrete roadbed) but a far cry from the public hazard associated with an uncontrolled release of the full amount.

At every incident, the team's specialty groups work independently and together, according to the data needs of their respective disciplines. Gathering and interpreting facts which will aid in the safe and speedy resolution of a spill may take unexepected turns. The police department of one city made an after-hours entry into a business office at HAZMAT's request to gain particular information about the characteristics of the MV Rio Neguen pesticide, aluminum phosphide. In another incident, a massive pentachlorophenol spill near New Orleans in 1980, a state patrol car made a 300-mile emergency run to get a library manuscript into the hands of NOAA trajectory modelers working at Coast Guard offices in New Orleans.

More routinely however, it is a combination of references in the Seattle HAZMAT library, its subscription computer data bases, countless phone calls to manufacturers and other exports, and experience developed from involvement at hundreds of spills that contribute to the reliable and useful advice and rapid response times consistently delivered by the NOAA team.

Behind the scenes, but an integral part of the service, is information management. The group directs computer applications

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specifically designed to facilitate the government's chemical emergency response. Accurate, clear, quick presentations of critical data and information are vital to the authorities on-scene. HAZMAT's role has been enhanced through a continuous involvement with the Coast Guard. All its information products are designed to support that perspective. As a result, the Coast Guard doesn't have to sort through the endless and potentially needless details that are available to NOAA which is on hand to evaluate relevant data technically.

To ensure a constant degree of quality and thoroughness in every response situation, HAZMAT goes through the data sorting and evaluation process before it provides any recommendation to the On-Scene Coordinator.

An example of this type of contingency planning product is a series of shoreline maps called Environmental Sensitivity Indexes, now complete for about 60 percent of the United States coastline. Starting in areas of high spill frequency and of greatest environmental concern, the locations and types of biological species most vulnerable during spills are pinpointed on each map In addition, various shore characteristics are identified according to the persistence of oil that would occur if it were to contaminate that shoreline type. Each beach type is assigned both a number and a color, from zero to ten and black to red, each corresponding to some degree from zero to maximum persistence. This allows the Coast Guard On-Scene coordinator to tell at a glance which threatened coastal areas should be protected first.

NOAA's chemical advisory reports are designed to accomplish before a spill much of the routine data gathering and interpretation that will be necessary wherever a spill occurs. For some of the most frequently spilled chemicals these documents are available in the HAZMAT central computer, ready for immediate transmission to the Coast Guard at the site. These reports provide, at a glance, a summary of the major sources of chemical product data. Each piece of data has been cross-checked and screened to prevent ambiguities, omissions, and redundancies in the data from interfering in an efficient spill response effort. For chemicals not yet on file, the data gathering and interpretation process and the computer system are designed to allow generation of new reports within an hour or two. A consistant format has helped HAZMAT to organize better its information while giving every Coast Guard officer throughout the nation another sense of constancy and familiarity with the NOAA Scientific Support Team.

Major HAZMAT Responses Since January 1979

:00DATE		LOCATION	TYPE
M/V Lee Wang Zin	12/25/79	Southeast Alaska	Sinking Ore Oil
F/V Ryuyo Maru #2	11/8/79	St. Paul Isl., AK	Grounding 220,000 Gal.
IXTOC Oil Well	6/3/79	Bay of Campeche, Mexico	Well blow-out
M/V Testbank	7/22/80	New Orleans, LA	Chemical still 12½ Tons
M/V Al-Ind-Esk-A-Sea	10/20/82	Everett, WA	Vessel Burned 11,500 Petro. Products
Savannah Warehouse	9/29/83	Savannah, GA	Chemical fire
M/V Blue Magpie	11/19/83	Yaquina Bay, OR	Oil Spill 76,000 Gal.
M/T Mobil Oil	3/19/84	Columbia River, or &WA	Oil Spill 4,000 Barrels
M/V Eidia	3/29/84	Nauset Beach, MA	Grounding
M/V Rio Neuguen	7/27/84	Houston,TX	Explosion, Aluminum Phosphide
M/T Alvens	7/30/84	Galveston, TX	Oil Spill 3,200,000 Gal.
American Cyanamid	10/6/84	Linden, NJ	Explosion, Malathion
T/V Puerto Rican	10/31/84	San Francisco, CA	Vessel break-up 27-35,000 Gal. Petro. products
M/V A. Regina	2/15/85	Mona Island, Caribbean	Oil Spill 3000 Gal.
T/V Grand Eagle	9/28/85	Delaware River	Grounding 40,000 gal.

Over the years, HAZMAT has had the opportunity to develop and refine these and other approaches to meet the challenge of satisfying the simultaneous needs of science and oil and chemical spill management. More recently, there has developed a new role for NOAA—providing scientific and information management assistance to the Environmental Protection Agency in combating the problems associated with thousands of coastal hazardous waste sites.

To provide a focal point with NOAA to work with EPA on waste site problems, a new position called Coastal Resource Coordinator is being established within HAZMAT to serve in a similar capacity to that of the SSC with the Coast Guard. Individuals are now being assigned to EPA regional offices in Boston and Philadelphia. Their duties are to coordinate the information from NOAA and other environmental scientists, to review NOAA trusteeship concerns and to help facilitate the waste site investigation and cleanup process.

NOAA and HAZMAT have quite a bit to contribute to the overall process of site research and management. For example, small-scale climatology is important in determining the spread and extent of contaminant migration away from the confines of the site itself and into coastal waters. HAZMAT personnel are working to improve the information to help determine the need and extent of cleanup efforts. Small-scale physical processes, including winds and surface water runoff, are also important to protecting the crews working on the site involved in the cleanup and sampling for off-site migration. HAZMAT is designing new chemical sampling and analysis techniques to help provide quick, inexpensive answers to the questions of what the chemical contaminants are and where they are going.

Another contribution concerns the electronic mail communications technology and methodologies HAZMAT has created for use by the government during spill emergencies. The storage and retrieval of sample, survey and other data are vital to the management of environmental emergencies.

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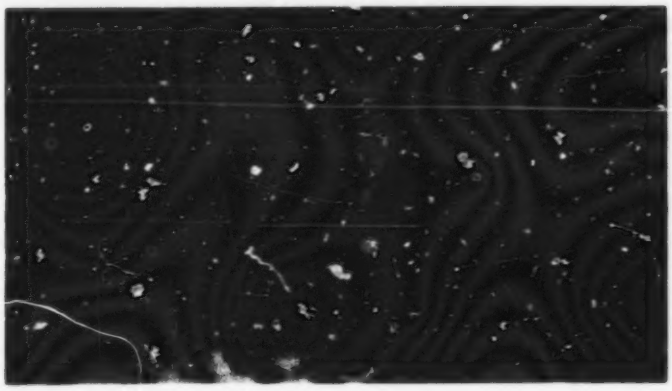
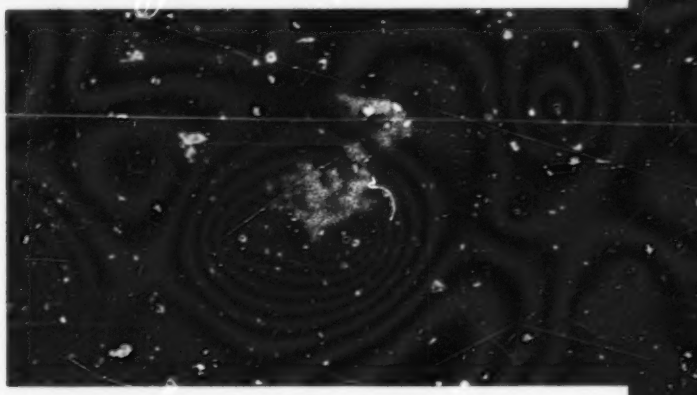
Rainmakers

Water, Water

Dr. Roger F. Reinking
Dr. William H. Hooke and
William J. Brennan *





Limits to global and national freshwater supplies are beginning to receive widespread government attention. The road sign in dry Nevada that pleads "Welcome to Golden Valley. Please Conserve Water," and the restaurant placard in Hawaii that gives notice that "Water will be served upon REQUEST. We're helping to conserve our island supply," reflect first signs of a major global resource problem. The next several decades will be punctuated by a series of water resource crises affecting localities, regions, and in some cases whole nations.

The United States is not immune. The Congressional Office of Technology Assessment (OTA) in a 1983 study of "Water-Related Technologies for Sustainable Agriculture in U.S. Arid and Semi-Arid Lands" noted that half of the western U.S. is experiencing water supply problems now, and reached some sobering conclusions: the demand for and expense of water, the depletion of ground water, salt and chemical buildup, water quality deterioration, and shifts to urban use all will accelerate to impose economic and social problems for the region and the nation in the late 1980's and the 1990's. Sustainability of western agriculture, which contributes 43 percent of U.S. farming income, "depends on the role the Federal government chooses or declines to play in the coming few years," according to the report.

To overcome growing shortages, which now are impacting the east as well as the west, only three courses of action are possible, the OTA believes:

- Use fresh water more efficiently.
- Better manage water, from stages of precipitation and runoff through collection, storage and distribution.
- Augment existing supplies.

Each alternative must be pushed, OTA concluded, but "the potential for a given technology to provide additional water or to conserve existing supplies is difficult to evaluate and will remain so unless the quantities of water involved in the hydrologic cycle can be defined more accurately."

Improvements through the first possible course of action lie with the user. Regarding the second, NOAA plays a vital supporting role in the national effort to manage precious water supplies. The River Forecast Centers of the National Weather Service combine quantitative precipitation forecasts and state-of-the-art hydrological models with snowpack and streamflow measurements to predict river runoff. These projections lead to public warnings, and provide essential support to operations of the Bureau of Reclaimation and the Army Corps of Engineers, those federal agencies directly responsible for water resources management.

Another, separate NOAA program—the NOAA Federal-State Cooperative Program in Weather Modification Research—addresses the third course of action: augmentation. Conducted by the Environmental Research Laboratories of NOAA's Office of Oceanic and Atmospheric Research, the program allocates a total of between two and three million dollars a year to Illinois, Nevada, North Dakota and Utah. The states, in turn, utilize the funds to evaluate and improve upon their respective on-going or planned operational programs in cloud seeding to enhance precipitation.

In spite of its small size, the program is changing the nature and scope of weather modification activities throughout the United States for two reasons. First, as its title declares, this is a cooperative federal-state program. Not just a state program. Not just a stand-alone federal program. A cooperative one.

The states are closest to the water resource problem; the difficulties experienced by farmers and ranchers as they draw down groundwater supplies, and face increasing energy and capital equipment costs. The states, too, are responding more directly to vocal and powerful constituencies calling for weather modification activities to support their economies and urbanization, and some have programs already in operation. The basis for the operational programs, as far as the users and supporters in the states are concerned, is that statistically it's a good gamble. A 60 to 70 percent chance of making it rain by seeding clouds is worth

*Dr. Reinking is Acting Director of NOAA's Weather Modification Program, an element of the Environmental Sciences Group of which Dr. Hooke is Director. Mr. Brennan is Public Affairs Officer at the Environmental Research Laboratories

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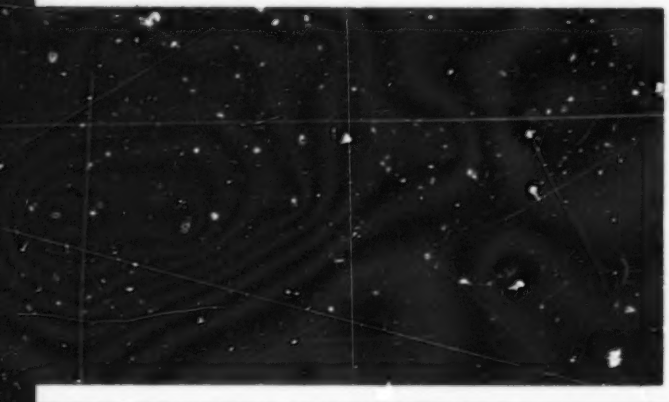
(But Not Everywhere)



In the 1960's attempts were made to wring moisture from the atmosphere by seeding clouds with particles of silver iodide. In this series, a cloud is seeded (first photo) and then photographed 9, 19, and 38 minutes later when the rainbearing cumulonimbus cloud is fully developed.

the uncertainties, given that the service costs only a few cents an acre. While the operators and users are satisfied with these odds, they would like to know if seeding actually is working, and if so, how to make it work better.

On the other side of the coin, most states find it difficult to mount and sustain programs of basic research needed to support and improve weather modification activities, and scientists are not satisfied with the present gambling odds. They want to know more accurately the physical and statistical realities of augmenting precipitation.

In contrast to the states, the federal government has substantial abilities to develop and run sustained programs of basic research in pursuit of acknowledged long range objectives. And, importantly, it is in NOAA's own best interests to define the realities of cloud seeding and, in so-doing, to learn more about the water budget of clouds and their precipitation efficiency. An effort of this sort, addressing the atmospheric portion of the hydrologic cycle, not only could permit more productive cloud seeding—the goal of the weather modification operators and users—but also better water management through more accurate quantitative precipitation forecasting, improved runoff prediction, better river flow forecasting, and improvements in other predictive areas in which NOAA elements have responsibilities. The mission of the NOAA Federal-State Cooperative Program in Weather Modification Research is "to support, conduct, and coordinate basic and applied research to understand cloud and precipitation processes and their role in the hydrologic cycle, under natural influences and with inadvertant and purposeful modifications."

The second reason for the program's effectiveness stems from NOAA's research capabilities in instrumentation—particularly remote sensors—and in basic research. The Wave Propagation Laboratory's radiometer for sensing liquid water has revolutionized the nature and impact of cloud studies nationwide. The K-band radar with polarization diversity permits study of liquid water droplets and ice crystals in clouds with remarkable diagnostic power. ERL scientists command a broad knowledge of the fundamentals of cloud microphysics and chemistry essential for success in weather modification, and they are more conscious than others that every effort must have a very solid scientific base; a rigid examination of the chain of physical events involving models, experimental design, confirmation, peer review; all the things signifying good science. Through research funding and collaboration, NOAA strongly influences the federal-state program.

The NOAA-North Dakota program provides a powerful illustration of the resulting synergism. The popular image of North Dakota is one gigantic, lush wheat field. The reality is quite different; the western half of the state is extremely dry, and studies suggest a 10 percent increase in growing-season rainfall there would mean a 20 percent increase in crop yield— not just wheat, but barley, oats, flax, corn, sunflow, hay, soybeans, sugar beets and potatoes. That amounts to a $180 million increase in annual production.

North Dakota is trying to realize rainfall increases through an operational cloud seeding program based on the accepted theory that if a seeding agent is delivered to the base of a young, growing cumulus cloud, updrafts will carry the agent throughout the cloud. Inside the cloud the agent will turn tiny cloud droplets to ice crystals, generating snow which will eventually fall out of the cloud as rain.

That's the theory, but until last year no one really knew if even the first step—the uptake into the cloud—actually happened. NOAA managers of the federal-state program suggested a simple research experiment: release a tracer along with the seeding agent, and determine its dissipation through the cloud using new, fast-response monitoring instruments.

The experiment was done, with sobering results. The clouds did indeed entrain the seeding agent. But the agent did not fill the cloud. Instead, it could be detected only as small vertical ribbons within the cloud mass, suggesting that an approach other than seeding at cloud base may be needed to deliver and spread seeding material through the whole volume of a cloud.

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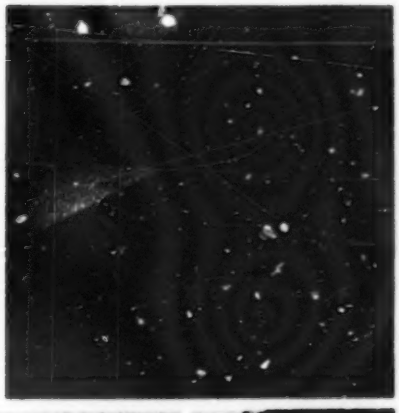
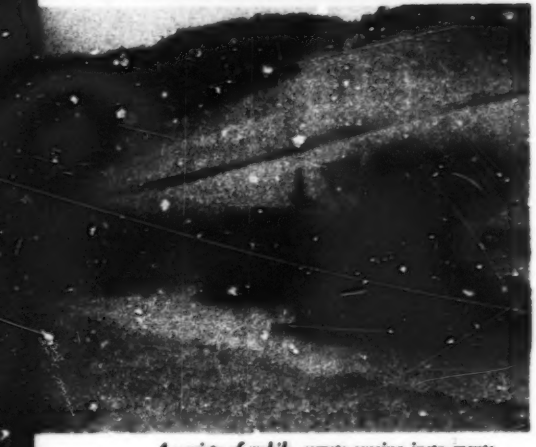
Nevertheless, the technique of using a tracer is offering tremendous diagnostic capability, and investigators nationwide—within and outside of NOAA—are rushing to adopt the technology in support of their cloud microphysics studies and, where appropriate, weather modification investigations. Not so incidentally, the technique applies equally well to determining how air pollutants are transported by convective clouds.





A variety of mobile, remote sensing instruments have been used in Utah's weather modification program. Top photo is of cloud particle measuring devices under the wing tip of a University of North Dakota aircraft.

Utah presents a different opportunity for NOAA to obtain new knowledge and provide supportive expertise. There, state officials are conducting an integrated study of the interaction between microphysics and mesoscale air motions in producing mountain snowfall. This includes a pioneering effort to determine if there is supercooled liquid water in "orographic" cloud, how much, over what space, and for how long a period. We need to know this before seeding, to give the operation a chance for success. And, we need the same information in research being done to monitor and predict the aircraft icing hazard.

With the guidance of NOAA scientists, Utah operators have used a suite of remote sensing instruments—radiometers, radar, lidar, and the like—to obtain a unique set of data on the water content and life cycles of winter storms.

The way in which these instruments have been used in the Utah program has demonstrated broader atmospheric research application potential for them than previously had been recognized, and the potentials for measuring cloud water budgets with these devices is enormous.

One does not have to look far to discover that each of the alternative water strategies delineated by the OTA has its limits, as the California State Department of Water Resources has learned. That state already is running out of alternatives: new construction of dams and aquaducts has been vetoed, desalinization of seawater is too energy intensive and far too underscaled to handle agriculture and urban water needs, and one of the few remaining alternatives is cloud seeding. The state presently is in the process of awarding contracts for studies of the possibilities of cloud seeding in the watersheds of the Sierra Nevada, adjacent to mountain areas where public utilities have operated such programs for decades.

In Nevada, some water users fear that such cloud seeding on the California side of the Sierra Nevada range may reduce the annual snowfall in that part of Nevada along the eastern slopes of the mountains. With NOAA help, the state is developing several new technologies for mapping air flow and chemical and microphysical snow-forming processes in clouds over mountainous terrain. In addition to confirming or allaying fears about the California seeding impact, and consequent potentials in Nevada, the new technologies are expected to have application to NOAA studies on atmospheric transport of acid rain precursors and other contaminants in wet weather over complex topography.

Illinois, unlike the other states in the cooperative program, cannot be considered a dry state. On the average, 45 inches of precipitation fall each year. Too, Illinois is in the heart of America's most productive agricultural area. Yet, on average, every 2 years the state gets only 50 to 60 percent of normal precipitation, and droughts with only 30 to 40 percent of normal rainfall occur with a ten-year frequency. If weather modification can offer a way to keep production up in the drier years, area farmers want to know.

The NOAA-Illinois program uses NOAA resources to help fund the Precipitation Augmentation for Crops Experiment, an ambitious study including not only the establishment of a sound scientific basis for cloud seeding, but a careful look at the agricultural, economic and social impacts of variations in rainfall for the state. To date Illinois has not done any seeding, directing its efforts to intense studies of experiment design, evolution of radar echoes from midwest convective clouds, and impacts of changes in rainfall on soils and crops in a systems context with heat stress, erosion and new agricultural practices.

In summation, the four federal-state programs are in four different climatic regions, yet address problems of both regional and national interest. Two are summer studies of convective rainfall, and two are winter programs concerned with snowfall. Importantly, it appears that what is being learned in each state can be extrapolated well beyond the state boundaries. These investigations are unique nationally and are expected to provide an important information base for widespread future weather modification policy formulation.

With water supplies dwindling, it's little wonder that weather modification—in particular the augmentation of precipitation by cloud seeding—is attracting considerable interest. Farming states look to convective cloud modification during the growing season as an alternative to irrigation and drawing water from aquifers. The mountain states look to snowpack enhancement as a means of increasing watershed supplies as well as spring and summer runoff. Whatever the reason, political and economic pressures from farmers, ranchers, and in some states ski resort operators, have led to operational weather modification programs in a number of states in this country, as well as in some 30 or 40 other nations.

Latest figures from the World Meteorological Organization indicate that (in 1981) some 2.4 million square kilometers of the world land area were within cloud seeding target areas. This includes 2.3 percent (221,000 square kilometers) of the total area, or 16 percent of the harvested area, of the United States, where some 45 or 50 operational cloud seeding programs are regularly being carried out. Russia has about a dozen such projects, Mexico has nine, and the trend everywhere is upward.

The future undoubtedly will be punctuated by a series of water crises, both at home and abroad. As these occur, NOAA responsibilities for water resource management and supporting research can only grow in scope and importance.

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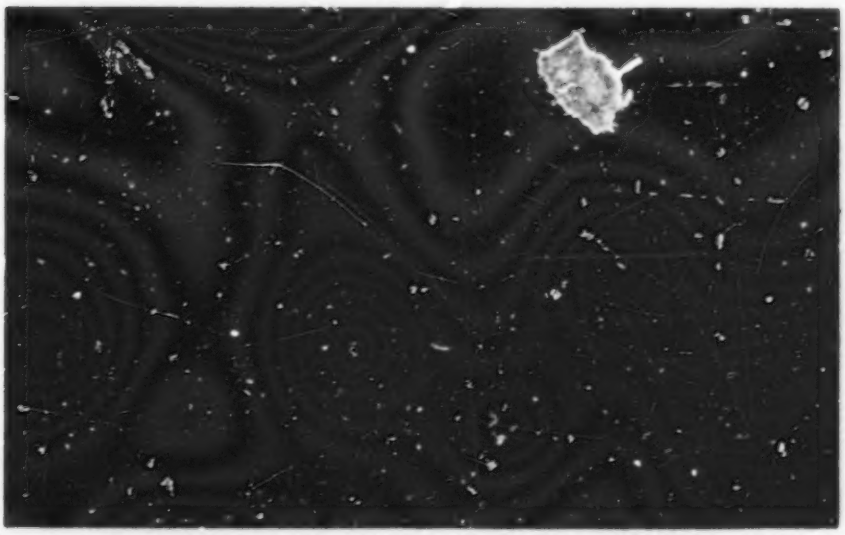
VIEW FROM SPACE

Weather Watching in 3-D



In these unusual, almost surrealistic views of the eye of a hurricane, the reader seems to be skimming the cloud tops above the giant storm, moving closer and closer to the swirling vortex.

The two photographs were not made from a high-flying airplane, though. They're satellite generated, and they show how computer techniques are used to produce displays of complex meteorological data sets to aid in their interpretation.

In this case, the National Aeronautics and Space Administration used NOAA-7 satellite data to create three-dimensional images of Hurricane Diana as she thrashed the seas off the Carolinas with 130-mile an hour winds on September 11, 1984.

The images were formed by "warping" or re-locating picture elements from the enhanced visible image of the storm received on one channel of the 470-nautical-mile-high satellite, based on the corresponding infra-red image received at the same time on a second channel. The infra-red image is a measure of the cloud top temperatures which are directly related to the closed top heights. So the relative heights seen in the three-dimensional image are based on these heights of infra-red image.

These photographs are 2 of a 44-image film loop produced by NASA in which the point of view was changed slightly in each successive frame to create a "moving picture," carrying the viewer on a remarkable journey across the top of a hurricane.

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NOAA - The First Fifteen Years

NOAA observed its 15th anniversary on October 3, 1985.

Created within the U.S. Department of Commerce in 1970 to promote increased knowledge and wise use of the natural environment, NOAA has evolved into the Nation's sea-air agency, studying the oceans, atmosphere, space, and sun, and applying this knowledge to products and services that benefit all Americans.

If the past is prologue, the years ahead for NOAA promise to be exciting ones. A review of only some of the agency's major achievements over its 15-year-history indicates the breadth of activities and the can-do attitude shared by NOAA workers.

Consider:

The Weather Service has automated its upper-air measurement system and is in the process of automating surface measurement systems. This automation relieves weather personnel from observing chores and allows them to concentrate on forecasts and warnings for the public.

To help guard against the dangers of floods, 1,300 satellite-reporting river gages have been installed by the Weather Service. In addition, local flash flood warning systems have been installed in hundreds of areas across the country with technical advice from the NOAA hydrologists, and a major prototype flash flood warning system has evolved in a five-state region in the Appalachian Mountains.

A system of about 40 data buoys ringing the nation's Atlantic, Pacific, and Gulf Coasts has been put in place by the National Weather Service to speed weather information from data-sparse areas for improved forecasts and warnings. Even more ocean weather data has become available through a program in which commercial fishermen and others serve as volunteer weather observers, calling in reports of ocean weather conditions to the National Weather Service. This program includes the coastal waters of southern New England, New Jersey to South Carolina, Washington State, Oregon, the northern Gulf of Alaska, the Aleutian Islands, and parts of the Gulf of Mexico.

The National Weather Service has completed a network of approximately 370 NOAA Weather Radio stations broadcasting continuous weather information tailored to the needs of people within the receiving area and emergency information when necessary. Approximately 90 percent of the Nation's population is within listening range of a NOAA Weather Radio station.

The National Environmental Satellite, Data, and Information Service has managed the operations of two different satellite systems providing weather and other environmental observations to meteorologists, oceanographers, hydrologists, geologists, farmers, foresters, and many others who now look to space to learn more about the world we live in. Imagery from NOAA spacecraft is familiar to most Americans in the form of the satellite weather photos used on television news shows.

NOAA's geostationary satellites orbit 22,000 miles above fixed points on the equator—providing continuous monitoring of environmental conditions over the continental United States, the Eastern Pacific and Western Atlantic Oceans. They pick out significant weather indicators—embryonic hurricanes at sea, thunderstorms, snow storms, and flood producing rains. They also relay information generated by ocean buoys and environmental sensors.

NOAA's polar-orbiting satellites spin around the earth 522 miles up relaying information on temperature, snow and ice field boundaries, solar activity, and global cloud cover. The polar system also collects data from fixed and moving platforms—such as drifting buoys—and accurately determines the locations of these platforms. The latest satellite in this series carries special instruments to relay the exact locations of ships and aircraft in distress to shore-based search and rescue facilities.

NOAA data centers maintain trillions of bits of stored information which constitute an invaluable environmental history of our age—an incalculably rich archive available to scientists and members of the public engaged in a wide variety of research and planning studies. The growth of these archives is illustrated at the National Climatic Center, Ashville, N.C., where storage of climate data has grown from 2,400,000 bits of computer information in 1970 to 108,800,000,000 bits in 1985. The Center's data is sought by a wide variety of users: insurers, environmentalists, and a major cross-section of the nation's industrial effort. Today, meteorologists at the Center handle as many as 5,000 requests for information each month.

Over the past 15 years, NOAA's fleet of oceanographic vessels worked with hundreds of scientists from universities, other federal agencies, and foreign countries on a wide range of oceanographic, geological, and meteorological experiments around the world. Hydrographic survey ships of the NOAA fleet continually surveyed all navigable U.S. coastal waterways providing up-to-date information for safe navigation by commercial shippers and recreational boaters. Other NOAA ships conducted fisheries research throughout the North Atlantic and Pacific, including waters off Japan, Canada, Mexico, and Central and South America.

NOAA's National Ocean Service produced nearly 1,000 different nautical charts and a range of chart-related products for use by the nation's many thousands of mariners—the pilots of all kinds of craft, from giant ore carriers to weekend pleasure boats—who depend on the meticulously prepared products for safe navigation.

NOAA has surveyed all U.S. airspace to produce approximately 10,000 aeronautical charts for air flights in the National Airspace System. Its charts help make America's aviation safer for thousands of pilots.

The National Ocean Service has replaced classical ground survey techniques used for the last two centuries with surveys using the newly developed Global Positioning System satellite technology which has improved accuracy and increased productivity at least tenfold, resulting in substantial savings to the taxpayer.

The National Marine Sanctuaries Program, administered by the National Ocean Service, saw the establishment of seven sanctuaries which will be protected to preserve or restore their unique conservation, recreation, ecological, or esthetic value. Through the establishment and careful management of these sanctuaries, a vital part of the nation's most valuable natural resources has been saved for posterity. The sanctuaries include the site of the sunken wreck of the U.S.S. Monitor off North Carolina the Key Largo Coral

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Reef, the Channel Islands off the coast of southern California, Looe Key off Florida, Gray's Reef off Georgia, Point Reyes-Farallan Islands off northern California, and Fagatele Bay in American Samoa. Fifteen national estuarine sanctuaries were established including South Slough, Oreg.; Sapelo Island, Ga.; Waimanu, Hawaii; Old Woman Creek, Ohio; Rookery Bay, Fla.; Apalachicola, Fla.; Elkhorn Slough, Calif.; Padilla Bay, Wash.; Narragansett Bay, R.I.; two sites on Chesapeake Bay, Md.; Jobos Bay, P.R., the North Carolina National Estuarine Sanctuary; Wells, Maine; and the Hudson River, N.Y.

Passage of the Magnuson Fishery Conservation and Management Act in 1976 marked a turning point for fisheries management in the United States. NOAA is charged with administering provisions of the act which controls foreign fishing in the Nation's 200-mile-wide conservation zone through domestic law and provides for the development of U.S. fisheries without depletion of fish populations. Since the Magnuson Act, NOAA fishery management specialists have seen the percentage of fish taken from the conservation zone by U.S. fishermen more than double, from 24 percent in 1976 to 50 percent in 1984. The value of all fish taken by U.S. harvesters from both state and federal waters reached $2.4 billion last year.

In addition, joint venture harvests by American fishermen, who sell their catches at sea to foreign processing vessels, has continued upward in recent years. Last year 1.5 billion pounds of fish, valued at $79 million were unloaded onto foreign vessels. This represents a substantial increase over 1980 when American joint venturers sold 137 million pounds of fish worth $8.3 million.

Meanwhile, the National Seafood Inspection program, using National Marine Fisheries Service inspectors located primarily near coastal areas where seafood is the economic mainstay, examined more than 483 million pounds of fish last year at the request of about 114 processing facilities and 300 seafood brokers to provide American consumers with safe and wholesome seafood products. The majority of the program's cost is paid for by the processors and brokers.

Fisheries scientists are conducting research on the value of fish oil in the American diet to prevent and treat coronary heart disease and evaluating ways to produce the oil for clinical testing.

NOAA fisheries scientists also were instrumental in the design of a special turtle excluder device installed in shrimp trawls, which releases alive 97 percent of endangered sea turtles caught in shrimp nets. Over 300 of the devices have been built for fishermen in the southeastern United States. Further development has led to a modification of the turtle excluder as a trawl efficiency device, since it also releases a high proportion of young, unmarketable fish, along with rocks, sponges, and jellyfish.

During NOAA's 15-year history, the agency's Office of Oceanic and Atmospheric Research has undertaken numerous research and development programs. The result has been significantly improved understanding of environmental processes, leading to such direct benefits to the American public as improved weather forecasts, profitable ocean enterprises, air and sea safety, and a clean environment.

NOAA laboratories have developed a variety of remote atmospheric sensors. Among them is Doppler weather radar which can identify cyclonic development within thunderstorms and has provided up to 20 minutes' advance warning of a tornado touchdown, for the first time giving those threatened adequate time to seek shelter.

Joining Doppler radar as important data-collecting systems to improve both short-and long-range forecasts are electronic methods for measuring winds, pressure, water vapor, and other constituents of the upper atmosphere; a radar system for remotely sensing offshore waves and currents; and a combination of radar and laser with the potential of "seeing" global winds.

Scientists at NOAA's Space Environment Laboratory are doing research on the space environment and high upper atmosphere to understand the interactions of Sun and Earth, and to give timely warning of disruptive events on the Sun to power companies, pipe line operators, marine transportation firms, and others who provide public services.

NOAA has identified sea-floor venting sites and accompanying mineral deposits in the eastern Pacific and the mid-Atlantic which may have vast economic potential for undersea mining concerns.

NOAA has played an active international role over the past 15 years. The agency has negotiated and then participated in a wide range of international living marine resource agreements including agreements to protect the great whales and North Pacific fur seals, to manage such international fish stocks as salmon and tuna, and to conserve Antarctic living marine resources.

Congratulations

NOAA's 15th anniversary was celebrated at agency facilities across the country last fall. In Washington, open house observances were held on the NOAA Ship Mt Mitchell and at several other D.C.-area locations. Administrator Anthony J. Calio was on hand to wish NOAA a happy birthday.

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Eat Fish to Your Heart's Content

Brian Gorman

Heart disease is the leading killer in the United States. Before this year is over almost 1,500,000 Americans will suffer a heart attack. More than half a million will die. Many of these victims will be hard working, vigorous men and women in the prime of life. The emotional and material costs of heart disease in the United States are staggering. The average coronary bypass surgery costs a cool $325,000. And last year there were almost 200,000 such operations. The total bill for all the costs associated with heart disease in 1984 was an estimated $72 billion.

Recently, however, there has been some promising news that may have a profound effect on these stark statistics. Last May the prestigious *New England Journal of Medicine* published the results of three studies that provide evidence that eating fish may, in the words of an editorial accompanying the studies, "be of special benefit to human health."

Each of the *Journal* studies, and others that have been conducted in the past several years, point to a relationship between eating fish and reducing the chances of heart attacks, apparently because of the special function of the oil in fish and shellfish. And eating even relatively small amounts of fish—about 3 ounces twice a week—had what the *Journal* called a "substantial protective effect."

Although the National Marine Fisheries Service and nutritionists for years have

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been touting fish as being good for your health, ironically it may turn out that the greatest benefits of fish in the diet depend not on its putative value as a low-fat food—something that was established long ago—but on just the opposite, the unique character of the oil found in all seafoods.

First, let's look at why seafood has traditionally been considered good for you. Fish is what's called a "nutrient dense" food; it has a very high ratio of protein, minerals and vitamins in comparison to calories. That means people who have to watch their weight—and lately that seems to include almost everybody—can get high quality protein and many other essential nutrients without taking in too many calories. This is especially true of the most popular white-fleshed fish like cod and haddock. A 3-ounce serving of one of these supplies about 18 grams of protein—40 percent of the average person's daily requirement—at a "cost" of only about 75 calories. By comparison, beef or pork, because they contain so much more fat, would contribute about 150 calories for the same amount of protein.

Another advantage of eating fish that has also been known for a long time is that, unlike red meat or poultry, fish is high in unsaturated fats or what are known technically as polyunsaturated fatty acids. Because of this fish can actually lower the cholesterol levels in the blood. A vital effect of lower cholesterol levels is a lower risk of heart disease. A recent study released by the National Institutes of Health shows that for every 1 percent we can reduce the serum cholesterol level in the blood, we get a 2 percent reduction in the risk of heart attack.

Finally, fish offers a remarkably diverse choice of species. While the meat counter of even a large, upscale supermarket may contain at most eight or ten varieties of meat and poultry, even the most unpretentious fish market may offer scores of different fresh species over the course of a year: a half-dozen types of shellfish, three or four kinds of salmon, two or three kinds of flounder, cod, haddock, halibut, ocean trout, mackerel, eel, smelts, red snapper, squid, shrimp, lobster, crabs, tuna and more. And that doesn't include salted, smoked, frozen or cured seafood.

The most exciting news about fish in the diet, however, is related to recently recognized, broad potential health benefits of fish in the diet, beyond its effect on cholesterol. Fish, in fact all seafood, contains unique polyunsaturated fatty acids known as Omega Threes. Seafood is by far the best source of these Omega Threes.

Researchers have been intrigued for years by the fact that in some cultures that have a diet very high in fish—Greenland Eskimos and certain Japanese fishermen and their families, for example—heart attacks are almost unknown. And clinical studies in the United States have suggested similar relationships between fish in the diet and lowered incidence of heart attacks. In one 19-year study completed more than a decade ago, Dr. Avery Fisher, a Seattle heart specialist, recommended that his heart patients eat fatty fish as a main course at least three times a week. The heart attack death rate was only 22 percent as high among those who followed Fisher's diet as those who did not. Moreover, the survival time of those on the fish diet who did suffer a subsequent heart attack was 109 months, in contrast to 38 months for those on a control diet.

In recent years, however, biochemists have begun to better understand the role of fats and cholesterol in the diet. Like fat, cholesterol is insoluable in water. It is carried through our blood by an envelope of proteins called lipoproteins. But researchers now know that there are two types of cholesterol, one associated with low density lipoproteins or LDL's and the other with high density lipoproteins or HDL's. It appears that the LDL's because they have the highest percentage of cholesterol attached to them, have the greatest potential for damage. It is the LDLs that do the dirty work of depositing cholesterol on the walls of our arteries. The HDL's by contrast, actually seem able to strip away cholesterol from cells and carry it to the liver where it can be removed.

It is here that the fatty acids, especially the Omega Threes, found in seafood seem to play the most dramatic role by increasing the "good cholesterol" or HDL production in the body and decreasing the production of "bad cholesterol" or LDLs. The Omega Threes thus may perform two important, in fact, lifesaving, functions. First, they may retard development of clot-forming blood cells called platelets and actually thin the blood, making it smoother and less sticky. Second, they may actually eliminate cholesterol deposits that restrict the flow of blood through the arteries.

Most coronary heart disease is brought about by a buildup of fat and cholesterol that circulates in the blood and is gradually deposited on the interior walls of the arteries, forming a thickened debris of plaque and scar tissue. Over the years these arteries, like old water pipes, become narrower and narrower, severely restricting the amount of blood that can pass through them. The chronic effect can be debilitating heart disease, characterized by shortness of breath, fatigue and an overworked heart. If the already clogged arteries are further restricted by a blood

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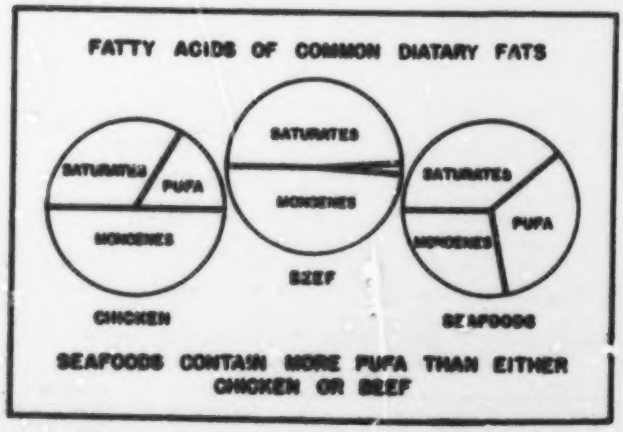
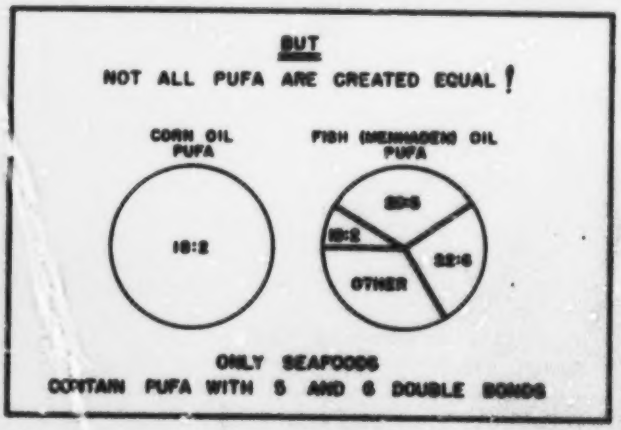
At the National Marine Fisheries Service Charleston Laboratory, Joanne Joseph (left) and Gloria Seaborn, Marine Lipids Team chemists, prepare an instrument that helps determine the structure and properties of lipids.





clot that blocks circulation to the heart, the result can be a crippling or even fatal heart attack.

Omega Threes may also alter the type or amount of a newly recognized class of compounds called leukotrienes that affect the body's inflammatory response. There are studies that point to encouraging beneficial effects on some of mankind's most wide-spread and debilitating chronic inflammatory diseases like arthritis, bronchial asthma and some forms of kidney disease.

In addition, in experimental work with mice, dietary supplements of Omega Threes significantly reduced the number and size of mammary tumors. Such studies suggest a potential role for Omega Three fatty acids in prevension of breast cancer in humans, although obviously much more work remains to be done.

Finally research with monkeys indicates that a lack of Omega Threes during pregnancy and early life of the newborn may impair the development of vision. Omega Threes help the cells in the retina to be stimulated, and a deficiency of these essential fatty acids can reduce sharpness of vision.

Moreover, the possibility that there are similar effects of the stimulation of brain cells, involved in learning and behavior, is being studied. Because Omega Threes are prevalent in parts of the human brain, some researchers theorize that a nutritional deficiency of these compounds might impair intellectual function. Perhaps the old saw that "fish is brain food" may be more correct than anyone has suspected.

Yet, as exciting as these research results are, we are still a long way from knowing exactly how Omega Threes work or even how much of them—or of the fish oil that contains them —is necessary for any effect to take place.

In an effort to find out the answers to at least some of these questions, the National Marine Fisheries Service, the National Institutes of Health and the National Fisheries Institute convened a conference last June in Washington, D.C. More than two dozen of the country's leading medical and biochemical researchers presented their findings and recommendations to almost 150 of their colleagues at the conference. The scientists were cautious, admitting that they need more clinical and laboratory studies before they will be in a position to make a rational judgement about the role of seafood in the diet, although there was general agreement that we should all eat more fish. The participants were also extraordinarily upbeat about the prospects of success and about the future of fish oil research.

And the research will continue. The National Institutes of Health expects to sponsor several major clinical investigations over the next few years, and researchers will for the first time be using a standardized source of fatty acids derived from fish oil, supplied by the National Marine Fisheries Service. Several tons of refined menhaden oil will be processed to yield about 10 kilograms of purified fatty acids to be used in NIH-sponsord research.

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Wallops Station

NOAA's Satellite Signal Callers

Bud Litin

Along Virginia's coast, on the fringes of a birdwatcher's paradise—the Chincoteague National Wildlife Refuge—stands a unique weather facility that serves the entire world via "birds" in space. It's NOAA's Wallops satellite communications station.

At Wallops, images and data are collected around the clock from NOAA's weather satellites high above the Earth. The satellite products are transmitted by way of NOAA's Satellite Operational Control Center in Suitland, Md., to National Weather Service forecasters and meteorologists on several continents.

The Wallops station provides the first Earth contact with NOAA's two families of satellites which produce global weather observations for the American public—and the entire world. The spacecraft include the "NOAA" series orbiting the Poles at

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Teams of experts daily shepherd the delivery of millions of bits of information from space. One such team (above) is Santos Rodriguez, shift supervisor Ken Fuln, Phil Luchich, Arch Connelly, Jim White, and Bill Mears. "Please deliver this yesterday" are familiar words to Paula Gregory and Barbara Knight (above right) of the "can do" logistics team at Wallops. At right, ADP specialists Al McMath and Mitch Green help maintain the health of Wallops computers.

470 miles altitude, and the "GOES" series which gather and relay information from their geostationary perches 22,000 miles above the equator.

Satellite information passed through the Wallops station enables early warnings of severe weather build-ups in the Atlantic, Pacific, Gulf of Mexico, and over continental areas— build-ups which bring such occurrances as 1985's hurricane Gloria, the rash of tornadoes, flash floods, and winter storms that have been in the news over the past months.

During, 1985 Wallops—its cluster of white dish antennas resembling a patch of giant mushrooms—began a $12 million upgrading. The program includes new, highly complex electronic circuits, comprising specially designed data processing and guidance networks. Improvements to be completed by mid-1986 will equip Wallops to handle an increasingly more efficient line of weather satellites operating to the year 2000.

Additions at Wallops will include a greatly enlarged operations building, plus equipment which will enhance both the quality and speed of delivery of satellite weather information, including images such as are displayed on home TV screens every evening.

The new installations and the heightened capabilities they make possilbe are:

- a new monitoring and control system for transmitting commands to, and receiving telemetry from, the GOES geostationary satellites.
- a new system for processing images of the earth and its atmosphere produced by all-weather infrared sounders aboard the GOES spacecraft (improved pictures of severe weather that is likely to result in hurricanes, tornadoes, tidal waves, snow and ice storms—the system that also produces daily cloud maps reproduced by newspapers and TV stations)
- a new processor distribution unit that will extend the flexibility of NOAA's Western Hemisphere weather data service.
- a specially designed, one-of-a-kind display monitor that will enable weather satellite technicians to watch constantly the incoming observations and make necessary adjustments to maintain higher quality images and data than now possible.

To mark completion of the refurbishing project, which coincided with NOAA's 15th Anniversary, Dr. Anthony J. Calio, Administrator of NOAA, officiated at ceremonies dedicating the station to the memory of two pioneer Weather Service scientists, Drs. Francis W. Reichelderfer and Harry Wexler. A bronze plaque to be mounted on the Wallops operations building was unveiled.

Dr. Reichelderfer was a pioneer aviator and meteorologist for the first trans-Atlantic airplane flight by the NC-4 in 1919. He later served as Chief of the U.S. Weather Bureau from 1938 to 1963. He and Dr. Wexler, who headed the bureau's

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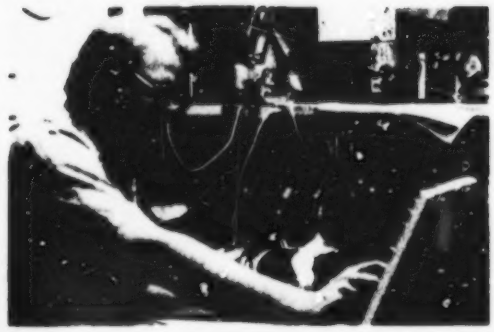

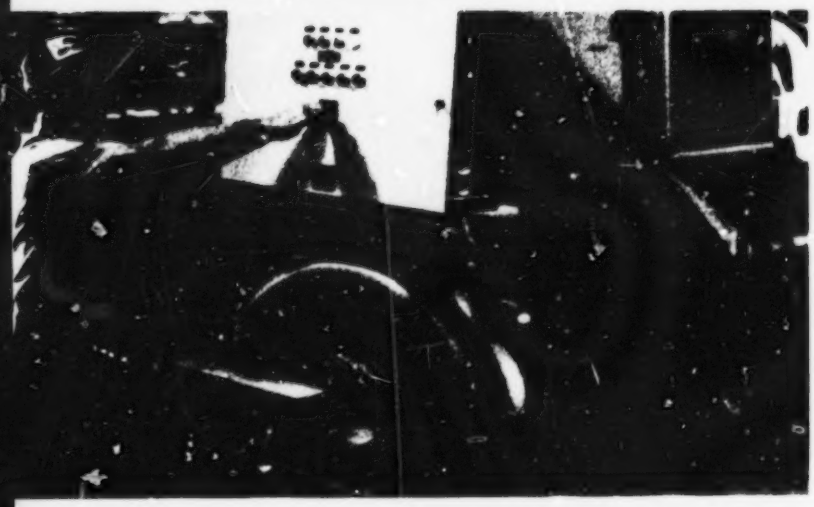

The Wallops Station operations building (top left) with geo-stationary satellite antennas in background. Helping to keep Wallops on the air are Jim Mason (top right) calibrating precision instruments, Tom Hall (above) at the controls in the power gear room, and Charles Dennis (left) monitoring the station's independent power systems.

scientific division, worked in tandem to develop what has become today's world-wide weather satellite system.

More than 100 highly trained men and women are required to operate the Wallops station. Their actions are coordinated with NOAA's Satellite Operations Control Center (SOCC), in Suitland, Md, about 150 miles away. The Suitland center is in constant contact with the World Weather Building at nearby Camp Springs Md, and with the Weather Service's Severe Storms Center at Kansas City, Mo. During hurricane season the National Hurricane Center at Miami becomes the focus of action for the entire team.

Wallops also is a world-wide search and rescue relay station for ship-wrecked sailors and downed fliers. The largest of seven dish antennas at Wallops towers more than 100 feet in the air. It services exclusively the polar-orbiting NOAA class satellites which carry instruments that can pin point within a few miles the location of ship wrecks and plane crashes as they did in the 1985 Air India crash in the Irish Sea. GOES-G, to be launched in the spring, also will carry a search and rescue transponder.

The Wallops staff embraces a wide range of skills—electronics specialists, engineers, computer technicians, even machinists, all of whom pride themselves for "can do" ingenuity.

The station boasts a well-equipped machine shop which has paid for itself many times over and where they have been able to design and produce difficult to replace components. In fact, the entire array for a complex electronics/control installation was designed and fabricated recently.An interface for a GOES atmospheric sounder system, which could have cost something like $300,000 if purchased outside was designed and built on site for about $3,000.

The people of Wallops also pride themselves for their civic-mindedness. They live in some quaint-sounding places like Chincoteague, Snow Hill, Pocomoke, and Onancock, where they are heavily involved in church activities, youth counseling and training, and as volunteer firemen and paramedics.

Station personnel serve as volunteer tutors in high school French, Spanish and mathematics. They also train youth rifle teams and the daughter of one employee has qualified for the 1988 U.S. Olympic rifle team in Korea. As part of a NOAA-wide "adopt-a-school" program the station has also adopted the Pocomoke City, Md., Middle School

Wallops, located in what is known as the "Eastern Shore Country" of southern Maryland and Virginia, is adjacent to possibly the nation's premium oyster beds off Chincoteague, Virginia. And when these global weather watchers' eyes get bleary from observing NOAA's "space birds," they can drive a few miles for some real live bird watching at the neighboring Chincoteague National Wildlife Preserve.

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Teen Talent

Encouraging Tomorrow's Marine Scientists

Dane Konop

Student Tanya Smith and her supervisor Michael Magil of the Satellite Experiment Lab of the NESDIS Office of Research and Applications discuss an overlay depicting weather conditions in Hurricane Bob. Tanya who worked on a case study of severe weather, has a flair for drama, but it was her straight A's in chemistry that got her a summer science job with NOAA.

Wendy Lau (left) and Charlene Yin at work on NOAA's National Coastal Pollutant Discharge Inventory in the Strategic Assessment Branch of the National Ocean Service in Rockville, Md.

Are you a NOAA scientist or engineer? Are you a male scientist or engineer? Are you a white, male scientist or engineer? Take a look around your office. Does everyone look a lot like you?

If you answered "yes" to these questions, and you think about it a little, you may reach the same insight informally that the National Science Foundation has determined formally with numbers. Most scientists and engineers in the United States are white males.

In fact, the National Science Foundation recently reported that while science and engineering jobs increased 50 percent from 1976 to 1983, in 1983 only 2 percent of employed scientists and engineers were Hispanic and only 2.8 percent were Black.

Some information will always be processed by hand, as Andrea Lisbicum found out in her work at the National Oceanographic Data Center in Washington.

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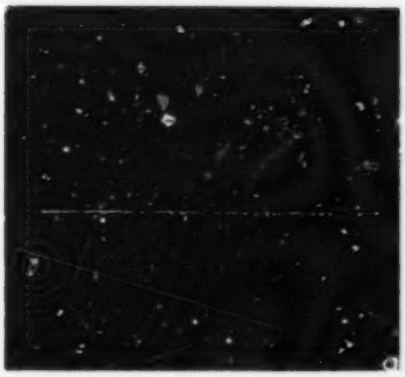
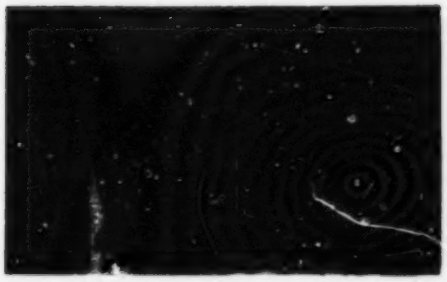


Dr. Houston Conley representing the District of Columbia Public School System lauded the successful completion of the fourth year of the program at the closing banquet in Washington.

Student Angela Johnson worked on a variety of computer systems while assisting the National Ocean Service's Dr. Ron New.



Because of the importance of having good language skills in careers in science, all students in the engineering/science summer program attended a communications workshop and wrote reports on their work experience with NOAA. Dwayne Hall was one of five students chosen to present his report at the program's closing banquet, while Dr. Elbert L. Cox, coordinator of the program and a faculty member at Howard University, looked on.

Ms. Terry Chewning, program coordinator for NOAA from the Office for Civil Rights, outlined NOAA's 4-year participation during the programs closing ceremonies. (Pictured also from the left, Howard Grimmett, Director of the NOAA Office for Civil Rights, and Dr. Elbert L. Cox of Howard University.

Summer students and their families were joined by the students' supervisors and other program participants at the closing banquet in Washington. (Pictured in the foreground from the left, Phillip Atkins, marketing specialist in the Industry Development Division of the National Marine Fisheries Service, Maurice Ward, NMFS Equal Employment Opportunity Coordinator, and Ms. Gloria Walker, EEO Coordinator for the National Weather Service.

Although the report showed that women have made significant employment gains in recent years, only 13 percent of scientists and engineers are women.

Howard University and NOAA facilities in Washington, D.C., have just finished the fourth year of a program that is helping to change this imbalance. It's called the Marine Engineering/Science Career Orientation Program and its purpose is to draw talented women and minority students into the ocean sciences and marine engineering. This past summer, 26 Washington-area high school students were employed as summer student-workers in scientific and engineering jobs at various NOAA facilities in the Washington area.

The program was conducted by the District of Columbia Metropolitan Consortium for Minorities in Engineering, Inc., through a gra to Howard University administered by the NOAA Sea Grant Office. To be eligible, participants had to be superior science or math students recommended by their school's science faculty, about to enter their junior or senior year of high school.

According to Dr. Thomas Murray of the Office of University Affairs in the NOAA Office of Oceanic and Atmospheric Research, a key goal of the program has been to increase the number of women and minorities in science and engineering professions by providing actual scientific and engineering work experiences to talented students.

The NOAA student workers were more than summer "gophers." They participated in actual scientific or engineering work being done by NOAA. One student, Tanya Smith from Woodson Senior High School performed severe weather analyses at the World Weather Building in Suitland, Md. Many of the students were assigned computer related jobs, including Andrea Linthicum, also of Woodson, who developed a system that will analyze and show an audit trail from 3 years of cost and production data at the National Oceanographic Data Center. Two students, Edna Ekuban of Cardoza Senior High School and Ian Auld of Wilson Senior High School manipulated tide and water level data in the Tidal Analysis Section of NOAA's National Ocean Service.

The NOAA summer student-workers, their parents, NOAA supervisors, and their teachers joined eight other Washington area students who worked for the summer at the Department of Energy and the Goddard Space Flight Center August 30 for a banquet recognizing their participation.

Program organizers realize that two dozen or so minority students working for a summer for NOAA won't correct imbalances in the science and engineering work force overnight. But the program is a step in the right direction—toward fairness in employment and diversity in the workplace.

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On the Coattails of a Nor'easter

Don Witten

One minute it's a low pressure system off the coast of Cape Hatteras. Twelve hours later it's a powerful winter storm, driving north and eastward along the Nation's east coast.

The storm contains narrow bands of rain, freezing rain and intense snow. A deviation of 10 degrees in its forward track can mean the difference between a minor inconvenience or a significant disruption for a major east coast city, costing lives and millions of dollars in damage and lost productivity.

This is the infamous "Hatteras Low," which is known also as a nor'easter if it drives far enough to the north and east. Regardless of what it is called, it is difficult to forecast. Like a bomb, it can explode into existence, follow an erratic path, and change in forward motion as if directed by some devilish hand.

Researchers and forecasters will join forces this winter from mid-January to mid-March to focus special observations on the birthplace of the "Hatteras Low." Their goal is to learn more about the birth, formation and life cycle of such storms. The improved short range forecasts of coastal storms expected to result eventually from this project will benefit the coastal communities and maritime enterprises subjected to the fury and vagaries of these storms.

This unique project is called Genesis of Atlantic Lows Experiment. It involves forecasters and researchers from the National Oceanic and Atmospheric Administration, the National Science Foundation, the National Center for Atmospheric Research, the National Aeronautics and Space Administration, the Office of Naval Research, and a number universities, including North Carolina State University.

GALE project director is Dr. Richard Dirks of the National Science Foundation. He said that the primary objectives of this multi-million dollar project are to record and describe in detail the evolution of east coast winter storms, and to gain a better understanding of the large

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This photo, and the one on the opposite page show the devastating winds of a nor'easter on coastal areas. NOAA researchers are making special studies to learn more about the birth, [illegible] and life cycle of such storms.

and small scale features which evolve during the storm's formation and development. Another objective of the GALE project is to develop and test improved models for better simulation and prediction of east coast winter weather accompanying the "Hatteras Low."

A low pressure system generally is associated with foul weather, and it can intensify into a major storm, given certain conditions. It begins with a body of warm air, which rises because it is more buoyant than surrounding, cooler air. The atmospheric pressure in the center is reduced, hence the name "low pressure system." Surrounding air is pulled into the center to replace the rising air, which condenses at higher, cooler altitudes to form clouds and eventually snowflakes or rain. In cooling, the warm air releases energy to fuel the storm. High level winds blowing across the top of the storm contribute to its development much like wind blowing over a chimney helps a fire burn faster.

Dirks described a classic situation which reveals just how little is known about the genesis of the "Hatteras Low": "If you look at the weather maps, you can trace a storm traveling across the United States. Ultimately you can track it up the west side of the Appalachian Mountains where it dies. About the same time, you see a new low pressure center emerge over the Cape Hatteras area."

Just what is it that causes the new low pressure center to form off the coast of Cape Hatteras and to intensify overnight into a major storm? And equally important, what triggers and contributes to the development of the storm's various small scale features such as snowbands, rainbands and others?

Project GALE researchers hope to answer these and other questions, at least in part.

The boundary layer where the atmosphere meets the sea is of particular interest to the GALE Project researchers. One feature they want to examine is the zone where a shallow pool of cold air along the Appalachians meets a layer of warm, moist air produced over the coastal water by heat from the ocean.

"We think that ocean heat, particularly that from the warm Gulf Stream, is an important factor in the generation of coastal winter storms," Dirks said.

Dr. Ronald Lavoie of the National Weather Service's Office of Meteorology serves as the coordinator for NOAA activities in the GALE project. He noted that the numerous observations recorded during the 2-month GALE experiment will allow the researchers to examine how upper atmospheric conditions contribute to the intensity of a building, coastal winter storm.

Forecasters know that the energy from storm activity at the surface is derived in part from the circulation of the upper level winds. They also know that the path of storms is steered to some extent by these winds.

"One thing we want to determine is the combination of ingredients from both the lower and upper levels of the atmosphere, which contribute to the rapid development of these storms," Lavoie said.

The observational network to be utilized for the GALE Project will provide the most intensive look at the atmospheric structure of east coast storms. It includes the basic NOAA weather observation system augmented by state-of-the-art systems contributed by a host of organizations involved in the GALE Project.

During pre-storm and storm conditions, upper air disturbances will be detected and tracked eastward by balloon-lofted radiosondes launched every 3 hours from 40 National Weather Service sites. Normally, these stations collect upper air observations twice daily.

Once an atmospheric disturbance reaches the Appalachians, it will be observed by upper air and surface stations, ground radar, research aircraft and ships, offshore buoys and satellites. The use of aircraft ships and buoys will provide an extension of observational capabilities to several hundred miles at sea where few observations are normally available.

Researchers from NOAA's Environmental Research Laboratories will compare the characteristics of the precipitation bands in the observed coastal winter storms with those in hurricanes. Information critical to their task will be collected by Citation and P-3 research aircraft, both operated by the NOAA Office of Aircraft Operations. This data also will be of value to GALE Project researchers studying other aspects of the coastal winter storms.

"Essentially, we are trying to use our aircraft techniques to gain insight into coastal winter storms and contrast this with the structure of hurricanes about which we have learned a great deal using the research aircraft," said Dr. Robert Burpee of ERL's Atlantic Oceanographic and Meteorological Laboratories in Miami.

The Weather Service's National Meteorological Center in Camp Springs, Md., will support the GALE Project by pro-

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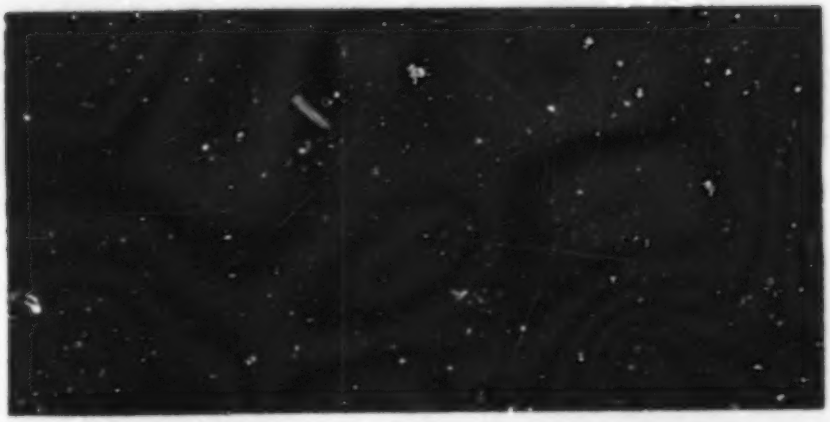
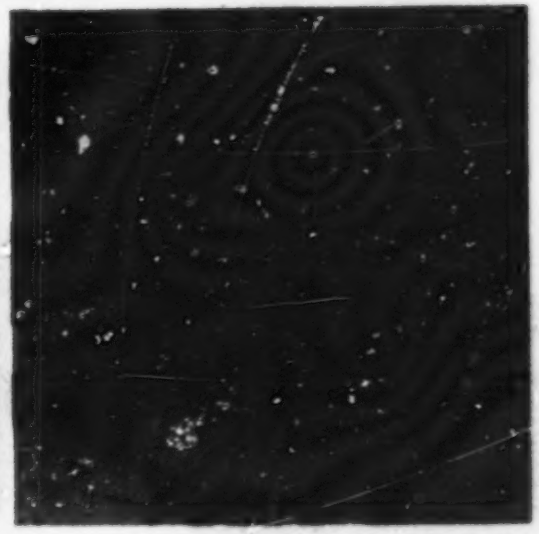


GALE's operations center is the Weather Service Forecast Office, Raleigh, N.C. The facility (top and bottom right) has the usual organized clutter of equipment. Bob Muller (at right in the photo below), who heads the Raleigh station, discusses logistics with Bill Barnhart, Area Electronic Supervisor.



viding forecast guidance based on current observations which are computer-processed with numerical models of the atmosphere.

Although numerical models constitute a major input to the forecasts and warnings prepared by the National Weather Service, they still cannot simulate a coastal winter storm's small scale features such as the precipitation bands associated with heavy snowfall.

"The main limitation we now face in this area is the lack of sufficient observations, particularly over the coastal waters," said Harlan Saylor, Chief of the Forecast Division at the National Meteorological Center.

"We will take this opportunity to determine the value of the intense GALE Project observations to the development of new, more detailed numerical models for improved forecasts and warnings of coastal winter storms," he added.

The center of operations for the GALE Project will be located at the National Weather Service Forecast Office in Raleigh, N.C. Bob Muller, Meteorologist-in-Charge of this office, said that special forecasts will be prepared for the deployment of the research aircraft and ships, which need lead time in order to be on station when a storm develops off shore. GALE Project scientists working in the forecast office will direct the operations of the aircraft and ships when they are on station in a developing storm.

Winter storms born off the coast of Cape Hatteras typically intensify as they move to the north and east, posing dangers to the Canadian Maritime Provinces. Hence, Canadian researchers will conduct a companion experiment to GALE to monitor the later stages of coastal storms as they move into Canada's area of forecasting responsibility. It is called the Canadian Atlantic Storm Project (CASP).

"This country is particularly interested in the small scale features of winter coastal storms because they produce the most violent conditions," said Dr. Herb Kruger, of Canada's Atmospheric Environmental Services, headquartered in Ottawa. Kruger is temporarily stationed at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, to coordinate CASP meteorological activities with Canadian oceanographers.

"We do fairly well on forecasting the large scale features of these storms because our numerical models focus on them. But advances in observing techniques and systems in recent years now allow us to gain a better understanding about small scale features so that we can improve our models and forecasts," Kruger added.

As in the past, any coastal winter storms developing this year will challenge the forecasting services of the United States and Canada as they pose hazards to the major coastal settlements in both countries. But the "good news" is that any such storms will be under the close scrutiny of a variety of atmospheric and oceanographic researchers whose efforts just might unlock some secrets invaluable to forecasters in both countries concerned with winter coastal storms next year and beyond.

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"Fish Is Heart Food!"

That's the idea receiving increasing attention in scientific and nutritional circles today, and with good reason as the article, "Eat Fish To Your Heart's Content," on page 16 of this issue of NOAA Magazine makes clear.

The following recipes were devised with your health, as well as your palate, in mind. They take advantage of fish that are rich in the oil that appears most beneficial to your health. And they are cooked with a minimum of salt and with polyunsaturated vegetable oils.

So, as you enjoy your next piece of fresh tuna or mackerel, remember: your heart will thank you as much as your tummy.

Herb Baked Salmon

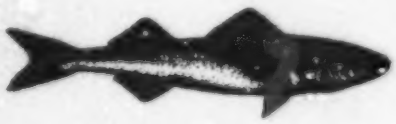
2 pounds of salmon fillets or steaks, fresh or frozen
1/4 cup herb flavored salad dressing
1/4 cup crushed herb-seasoned croutons

Thaw fish, if frozen, and place in a lightly oiled baking dish, approximately 12 x 8 x 2 inches. Pour salad dressing over fish, reserving about one tablespoon. Sprinkle crushed croutons over fish and drizzle with the reserved salad dressing. Bake in a moderate oven at 350 F. for 20 to 25 minutes or until fish flakes easily when tested with a fork. Makes six servings.

Baked Shark Steaks

2 pounds shark steaks, fresh or frozen
1/4 cup dry white wine
2 tablespoons olive oil
1 tablespoon chopped parsley
1 tablespoon reduced sodium soy sauce
dash garlic powder

Thaw fish, if frozen, and place in lightly oiled baking dish, approximately 12 x 8 x 2 inches. Combine remaining ingredients and pour over fish. Marinate fish for 30 minutes, turning once. Bake in a moderate oven, 350 F., for 20 to 25 minutes or until fish flakes easily when tested with a fork. Makes six servings.



Lemon Broiled Sablefish

2 pounds of sablefish fillets or steaks, fresh or frozen
2 tablespoons lemon juice
1 tablespoon olive oil
1 tablespoon brown sugar
1 teaspoon grated lemon peel
1/2 teaspoon salt

Thaw fish, if frozen, and place on a lightly oiled baking pan, approximately 15 x 10 x 1 inches. Combine remaining ingredients and pour over fish. Let stand for 15 minutes. Broil about four inches from source of heat for 8 to 10 minutes or until fish flakes easily when tested with a fork. Baste once or twice during broiling with pan juices. Makes six servings.

Broiled Tuna

2 pounds tuna steaks, fresh or frozen
2 tablespoons olive oil
2 tablespoons wine vinegar
1/2 teaspoon salt
1/4 teaspoon thyme
dash hot pepper sauce

Thaw steaks, if frozen. Combine remaining ingredients in a baking pan, approximately 15 x 10 x 1 inches. Place steaks in pan and turn to moisten both sides. Let stand for 30 minutes, turning once. Broil about 4 inches from source of heat for 8 to 10 minutes or until fish flakes easily when tested with a fork. Baste fish once or twice during broiling with the pan juices. Makes six servings.

Broiled Mackerel

2 pounds mackerel fillets, fresh or frozen
2 tablespoons lemon or lime juice
1 tablespoon olive oil
1 tablespoon grated onion
1 teaspoon seafood seasoning
1/8 teaspoon pepper

Thaw fillets, if frozen, and place skin side up on a lightly oiled baking pan, approximately 15 x 10 x 1 inches. Combine remaining ingredients and brush over fish. Broil about four inches from source of heat for 4 to 5 minutes. Turn fillets and brush with sauce. Broil 4 to 5 minutes longer or until fish flakes easily when tested with a fork. Makes six servings.

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